MINERALS

ECONOMIC & REGIONAL DEVELOPMENT AGREEMENT

Final Report
TASK 4 - Geotechnical Database
for Ground Control
Numerical Modelling
BEAP-M USER DOCUMENTATION

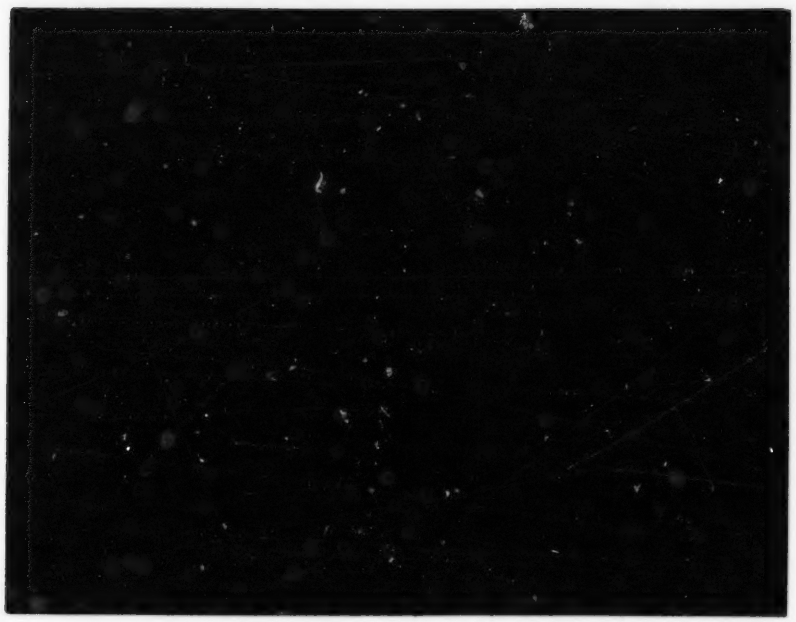
by

Inco Limited, Thompson Division
Thompson, Manitoba

March 1990

Canada

Manitoba



CANADA - MANITOBA

MINERAL DEVELOPMENT AGREEMENT

RESEARCH & DEVELOPMENT IN MANITOBA MINES

Work on the project was conducted under the auspices of Canada Centre for Mineral and Energy Technology, Energy, Mines and Resources Canada under the Canada/Manitoba Mineral Development Agreement.

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GEOTECHNICAL DATABASE FOR GROUND CONTROL

Numerical Modelling

Beap-M User Documentation

This has been prepared as part of the

TASK 4
Geotechnical Database for Ground Control
of the
Canada/Manitoba Mineral Development Agreement

by

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Sub-contracting to
Inco Limited, Thompson Division, Manitoba

DSS File No.: 14SQ.23440-4-9147-4
CANMET Project No.: 4-9147-4
CANMET Scientific Authority: Y.S. Yu

USER DOCUMENTATION

FOR

BEAP-M : VERSION 1.0

BOUNDARY ELEMENT ANALYSIS PACKAGE

MIXED BOUNDARY ELEMENT AND DISPLACEMENT DISCONTINUITY ELEMENTS

VOLUME 1 OF 1 : USER MANUAL

REF 54703 JANUARY 1990

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1.0 AN OVERVIEW

BEAP-M facilitates three-dimensional stress analysis of underground excavations which are tabular or massive in nature. It is an interactive package which has been designed and written specifically for application to mining problems. Excavation surfaces and optionally the earth's surface are modelled with boundary elements or displacement discontinuity elements. The element types used are square displacement discontinuity elements with constant variation of closures and tractions across each element and non-conforming quadratic boundary elements.

The package evolved from the boundary element package MBEM which already has been used or installed in many countries. BEAP-M is essentially a combination of BEAP and BEAP-DD and can only be run together with those programs.

1.1 APPLICATION AREAS

- Any problem which can be modelled either using BEAP or BEAP-DD.
- Analysis of a single reef or seam close to an open pit, a regular or irregular earth's surface (figure 1.1.1).
- Combined open and tabular excavation modelling.
- Reasonably regular open excavations intersected by a fault.

1.2 FEATURES

- IBM-PC/AT or compatibles
- Interactive or batch mode operation
- Uses user digitized polygons for layout definition for displacement discontinuity elements.
- Multi step capability
- Capacity of up to 256 lumps (6400 elements) or 19200 degrees of freedom and 256 boundary elements (2304 function nodes) or 6912 degrees of freedom for a possible total of 26112 degrees of freedom.
- Requires only 256 Kbytes of system memory.
- Named elements and benchmarks for easy user identification
- Use of iterative solution technique and lumping to reduce computing requirements
- Robust against user abuse with various re-start options
- Includes fault or non-linear backfill elements.
- Fully compatible with BEAP and BEAP-DD

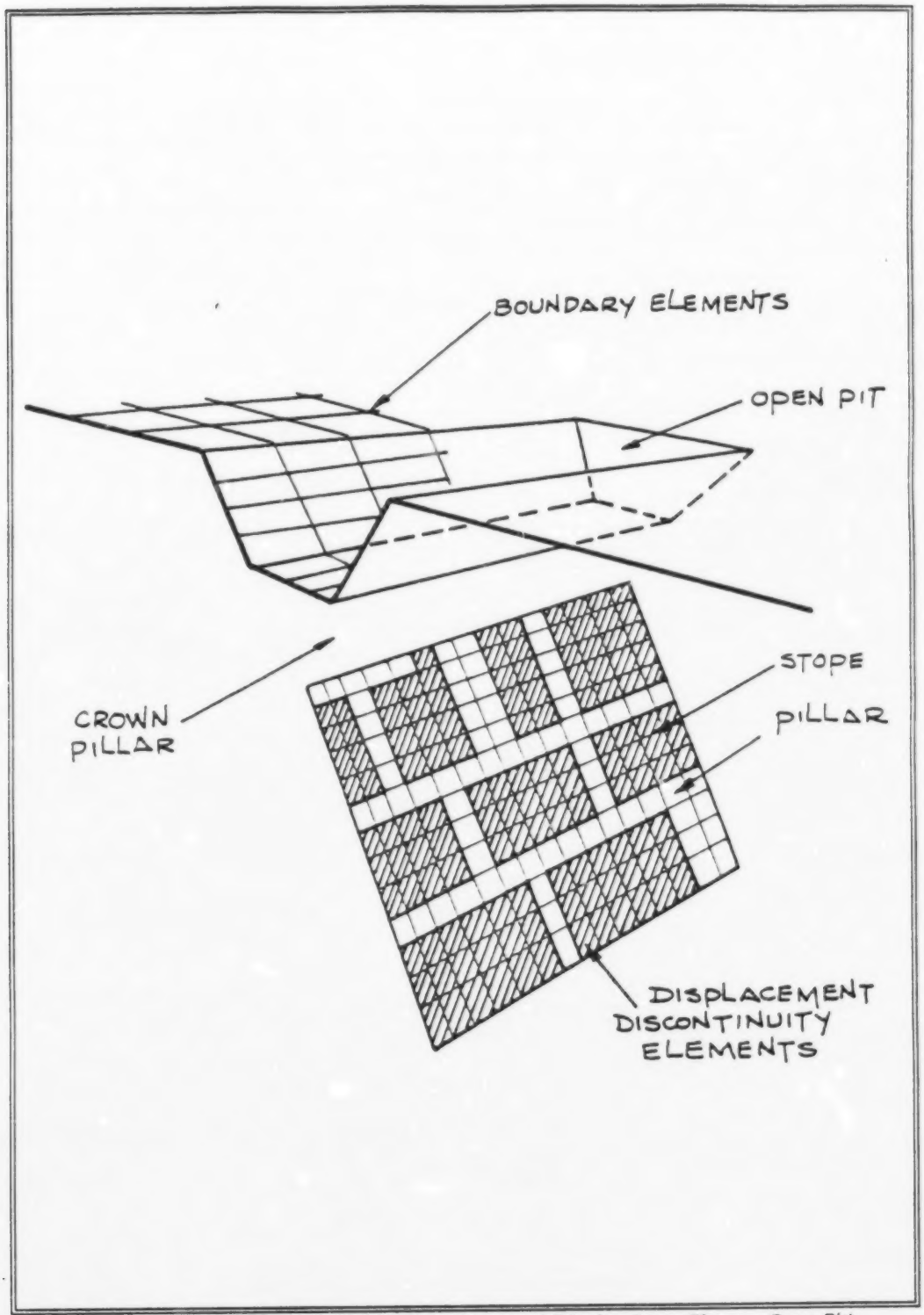

Figure 1.1.1: 'Ideal Application for BEAP-M: Underground Dipping Seam Close to Open Pit'

1.3 LIMITATIONS

- Currently set for a maximum of 100 X 100 displacement discontinuity elem for a single seam or less if multiple seams are used.

- Large problems may require long execution times. On IBM-PC type equipment (even using 80386 processors), overnight runs will usually be required. Disk space requirements will vary depending upon problem definition, but may be large in some instances.

- This manual has been prepared for the assistance and guidance of users of BEAP-M. Whilst care has been taken in the presentation of this manual, the user should treat results with due caution and engineering judgement. By the very nature of such programs, an in-experienced user can easily obtain erroneous results. Moreover, as there so many different types of problems which can potentially be analyzed by such a program, it is possible (and more likely probable that there will be program errors in some circumstances). Such errors can only be ironed after continued use and debugging of the program.

1.4 ABOUT THIS MANUAL

BEAP-M enables advanced elastic stress analysis of fully three-dimensional mining geometries to be carried out efficiently and economically.

This manual assumes that the user is already familiar with the concepts of three-dimensional stress analysis and with the use of the programs BEAP and BEAP-DD and the associated concepts of working with a three-dimensional geometry. For further information in this regard, the user is referred to the list of references listed at the end of the manual.

Section 2 of this manual describes installation procedures, while Section 3 describes the preparation of the input data files Section 4 describes each of the program modules making up the BEAP-M system. Procedures for running BEAP-M are given in Section 5.

Less experienced users are well advised to read through some of the papers listed in the references in Section 6.

1.5 GEOMETRIC NODES, LUMPS and ELEMENTS.

During the development of BEAP-M, a confusion of terminology arose regarding the terms lumps, elements, nodes and function nodes. In order to minimize this possible confusion, the following terms should be noted. For boundary elements, an **element** consists of 9 **function nodes** at which displacements and tractions are modelled. Each **element** is defined using from 4 to 9 global or geometric **nodes**.

For the displacement discontinuity portion of a model, use is made of displacement discontinuity **lumps**, each of which is divided up into 5 X 5 square displacement discontinuity **elements**. Each **lump** is defined using 4 global or geometric **nodes**. The same global nodes may be used for both boundary elements and displacement discontinuity lumps.

Figure 1.5.1 shows an the internal arrangement of elements within a single displacement discontinuity lump. Figure 1.5.2 shows the arrangement of nodes and displacement discontinuity lumps and boundary elements for a small test example.

Often, in this manual, BE is used to denote boundary elements, whilst DD is used to denote displacement discontinuity lumps and/or elements.

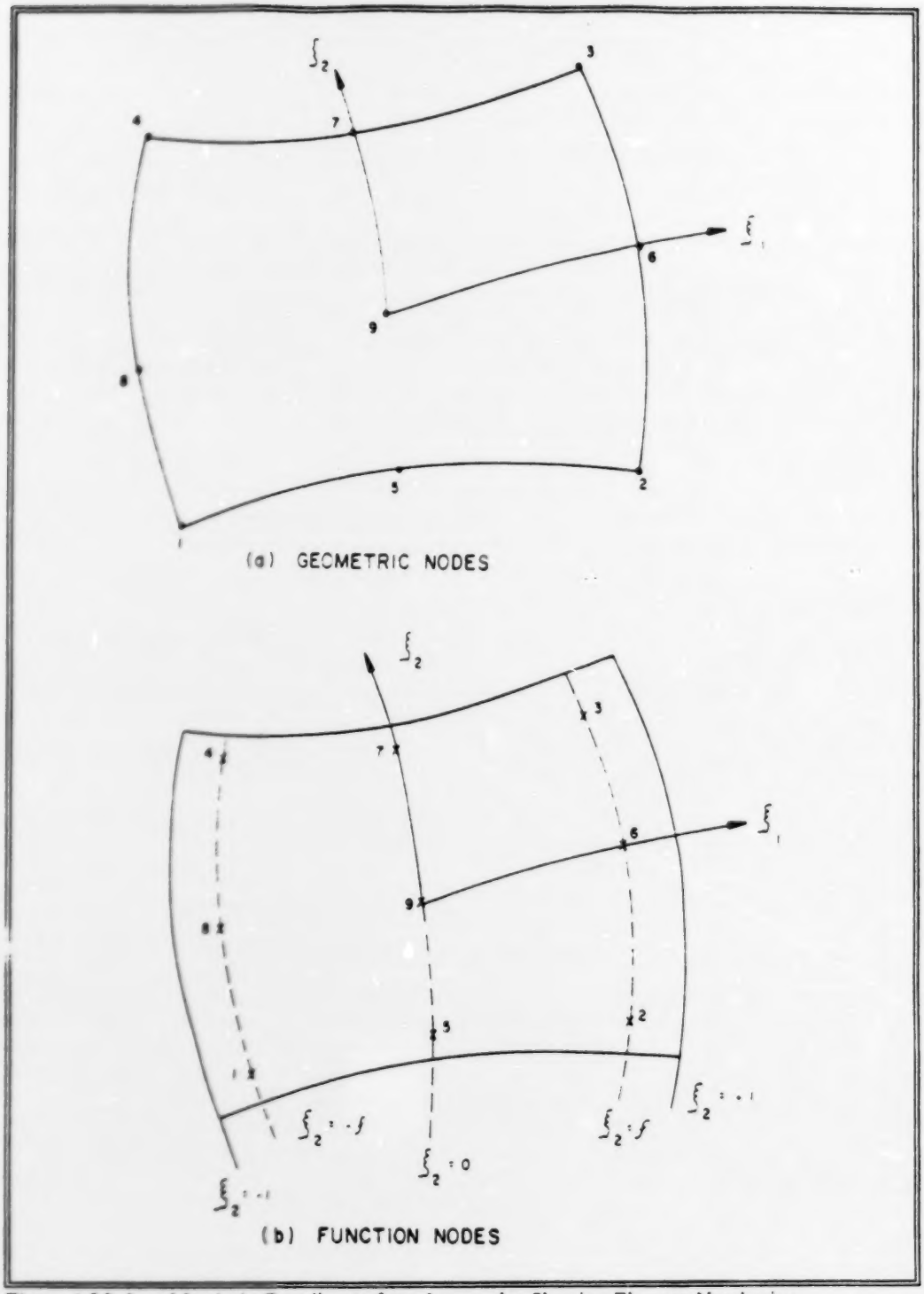

Figure 1.5.2: Local Intrinsic Coordinates for a Lump, also Showing Element Numbering

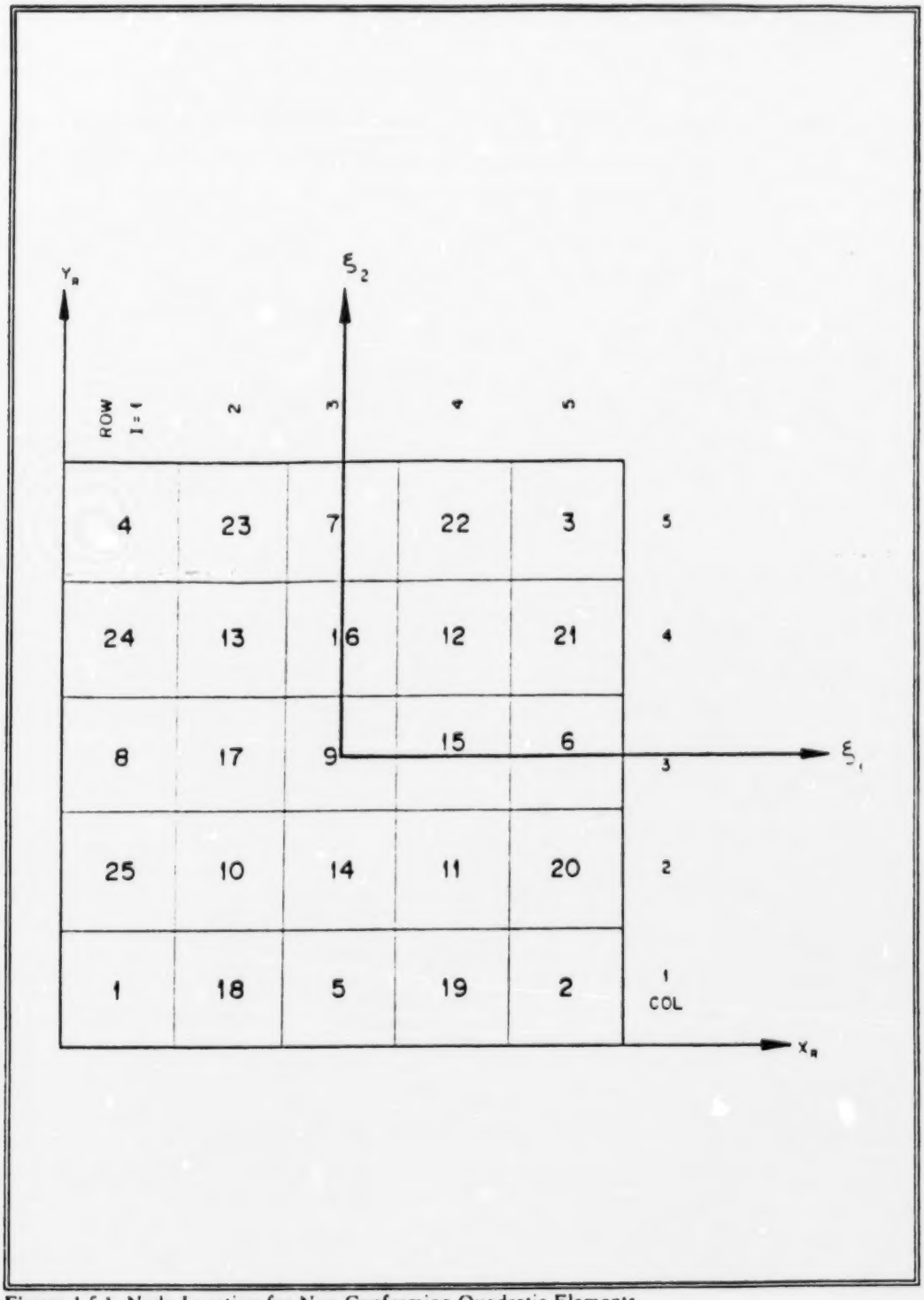

Figure 1.5.1: Node Location for Non-Conforming Quadratic Elements

2.0 INSTALLATION

The installation procedure described here applies only to IBM-PC compatible equipment running DOS.

2.1 GETTING STARTED

It is advisable to create a separate subdirectory which will contain the BEAP-M program modules. This would probably be the same as that used for BEAP and BEAP-DD, which should already have been installed and tested before installation of BEAP-M commences. A second subdirectory to contain the data files and database would probably be the same as those used for datafiles for BEAP and BEAP-DD. Let us call the program subdirectory 'BEAP' and assume that it is on the C Drive. Let us call the database subdirectory 'BEAPDATA' and assume that it is on the D Drive. If there is insufficient space on the C drive to install all of the executable code for BEAP-M, then it is still necessary to create a subdirectory C:\BEAP which MUST contain the message files for BEMPOST, BEAP and BEAP-DD.

The program modules occupy around 4 Megabytes of disk space. The test database supplied with BEAP-M is very small (less than 1 MByte). However, storage requirements for the database can be very large. At least 15 Megabytes should be available for medium-sized problems with 30 Megabytes or more for larger problems.

2.2 DATABASE FILES

The user is required to create several input data files. The exact file names can be defined by the user. File naming and descriptions for file preparation are exactly as for BEAP and BEAP-DD. When a new database is created using M101, numerous other data files will be created in the current subdirectory from which the program is being run.

Most of the database files are in binary code and cannot be usefully displayed by the user. There are program modules for decoding or displaying these files where necessary. Database files are as follows:

Used by BEAP, BEAP-DD and BEAP-M :

BEMCO.	BE	Influence coefficients (BE)
BEMMESH.	BE	Plot file of BE mesh
BEMMESHE.	BE	Plot file of BE element numbers
BEMMESHN.	BE	Plot file of BE node locations (as X)
BEMPOL.	BE	Polygon master file
BENSTOR.	BE	Benchmark file (Binary)
BOTH.	BE	Basic information (internal to program)
BVECT.	BE	Right hand side vector
LIND.	BE	Lumping maps for (BE)
LUMPS.	BE	Geometric information for BE elements
LUMSTOR.	BE	Detailed information for BE elements
LUMSTOR2.	BE	Second file for BE elements
SELFCO.	BE	Element self-coefficients (BE)
VARCOM.	BE	Basic information (to supplement BOTH.BE)
XN.	BE	Nodal coordinates
TEMP.	LST	printout file for results

Only used by BEAP-M

COEF.	BD	Influence coefficients (BE-DD)
LIND.	BD	Lumping maps (BE-DD)
BVECT.	DB	Right hand side vector
COEF.	DB	Influence coefficients (BE)
LIND.	DB	Lumping maps (BE-DD)

Used by BEAP-DD (and hence BEAP-M also)

BEMCO.	DD	Influence coefficients (BE)
BEMMESH.	DD	Plot file for DD elements
BEMMESHE.	DD	Plot file of DD element numbers
BEMMESHN.	DD	Plot file of DD node locations (as X)
BEMSTEP.	DD	Store information for multi step runs
BVECT.	DD	Right hand side vector
LIND.	DD	Lumping maps (BE-DD)
LUMPS.	DD	Geometric information for DD lumps
LUMSTOR.	DD	Result information for DD elements
LUMSTOR2.	DD	More information for DD elements
LUMSTORG.	DD	Geometric information for DD elements
POLPLOT.	DD	Plot file for polygons
SELFCO.	DD	Self effects for DD elements
SHEET.	DD	File to store spreadsheet information
STORSTEP.	DD	Store information for multi step runs

2.3 PROGRAM FILES

Programs may be run independently, or via the menu driver BEAP.EXE. Note that as so few modules exist in BEAP-M, which are not part of BEAP or BEAP-DD, these have been included as part of the menu driver for BEAP. The following .EXE files (as well as all those for BEAP and BEAP-DD) make up the BEAP-M system.

BEAP Menu driver for BEAP and parts of BEAP-M

DB501 Calculate lumping maps (DD-BE)
DB502 Calculate influence coefficients (DD-BE)

BD501 Calculate lumping maps (BE-DD)
BD502 Calculate influence coefficients (BE-DD)
BD504 Solve equations (MIXED BE+DD)
BD507 Calculate (MIXED) benchmarks

At the time of installation, all these .EXE files would be copied into the program subdirectory (for example C:\BEAP)

2.4 TEST DATA FILES

Two test data files have been included at the end of this manual to help new users become familiar with BEAP-M. The data files and examples are as follows:

BOX	Solid cube containing a single displacement discontinuity lump (see figures 2.4.1 and 2.4.2).
DREEF	dipping reef close to surface (See figure 2.4.3)

Any user running BEAP-M for the first time should ensure that the program can be made to run with one of these data files (which most closely matches has own problem) before attempting to run BEAP with the actual problem data.

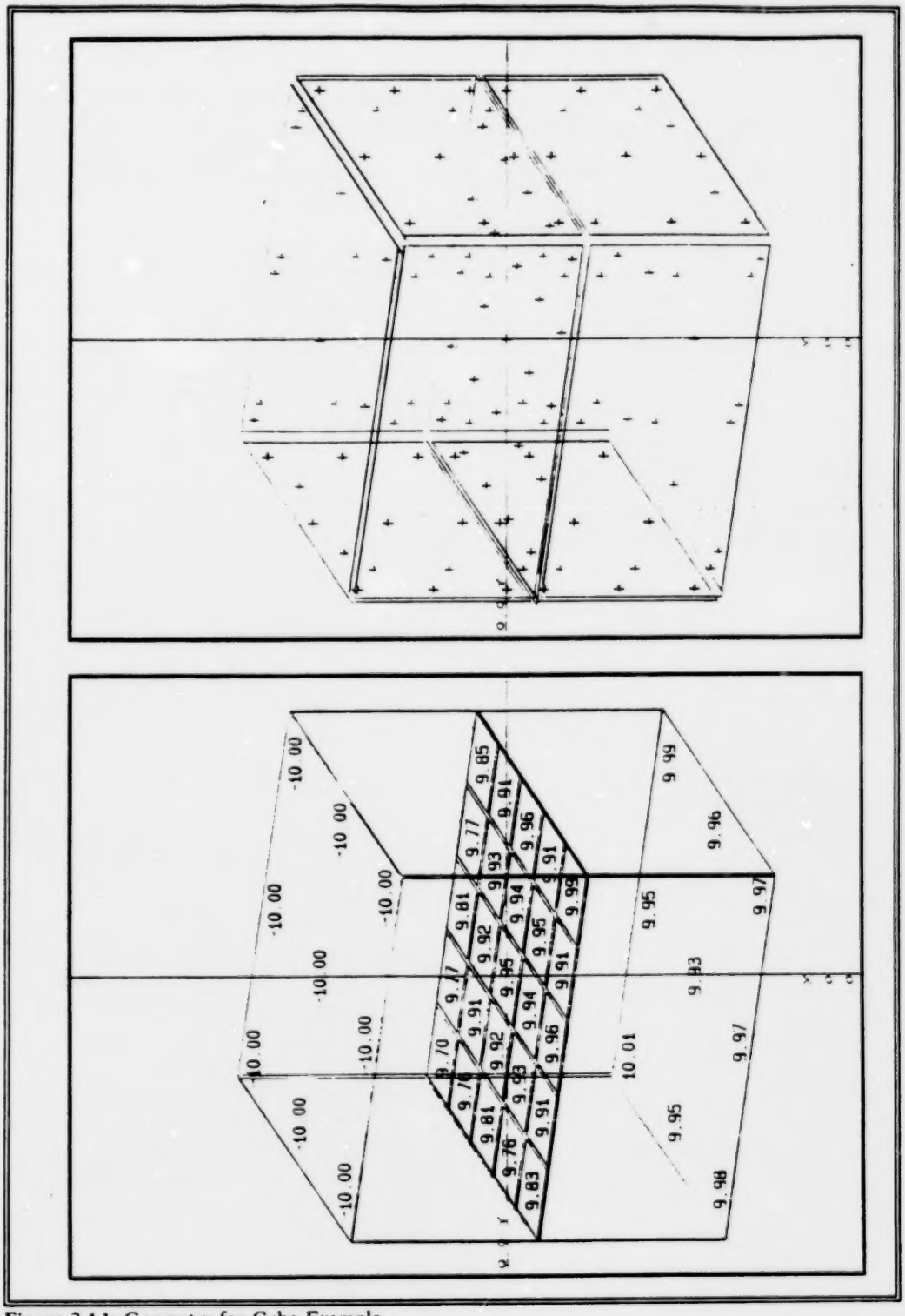

Figure 2.4.1: Geometry for Cube Example

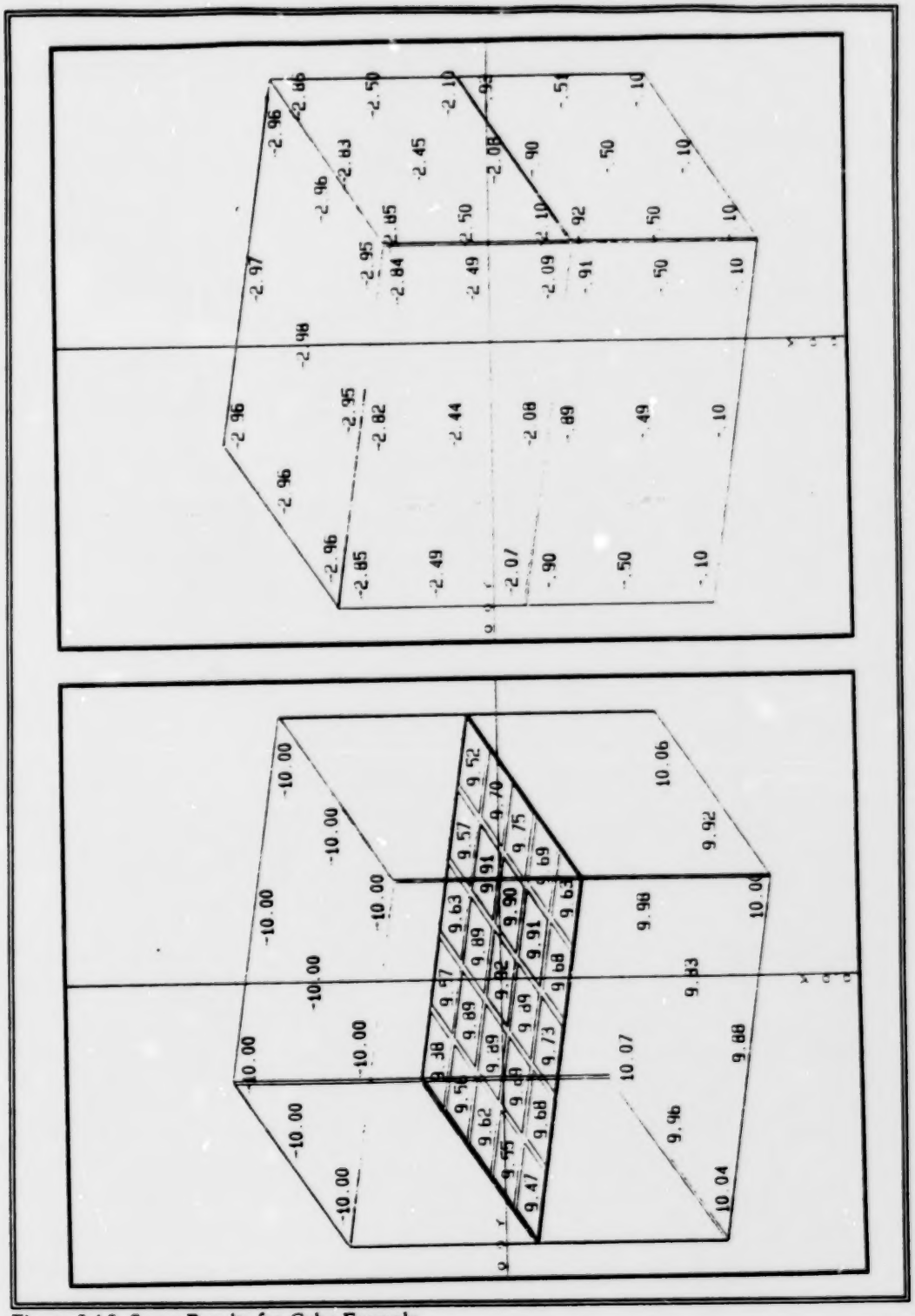

Figure 2.4.2: Some Results for Cube Example

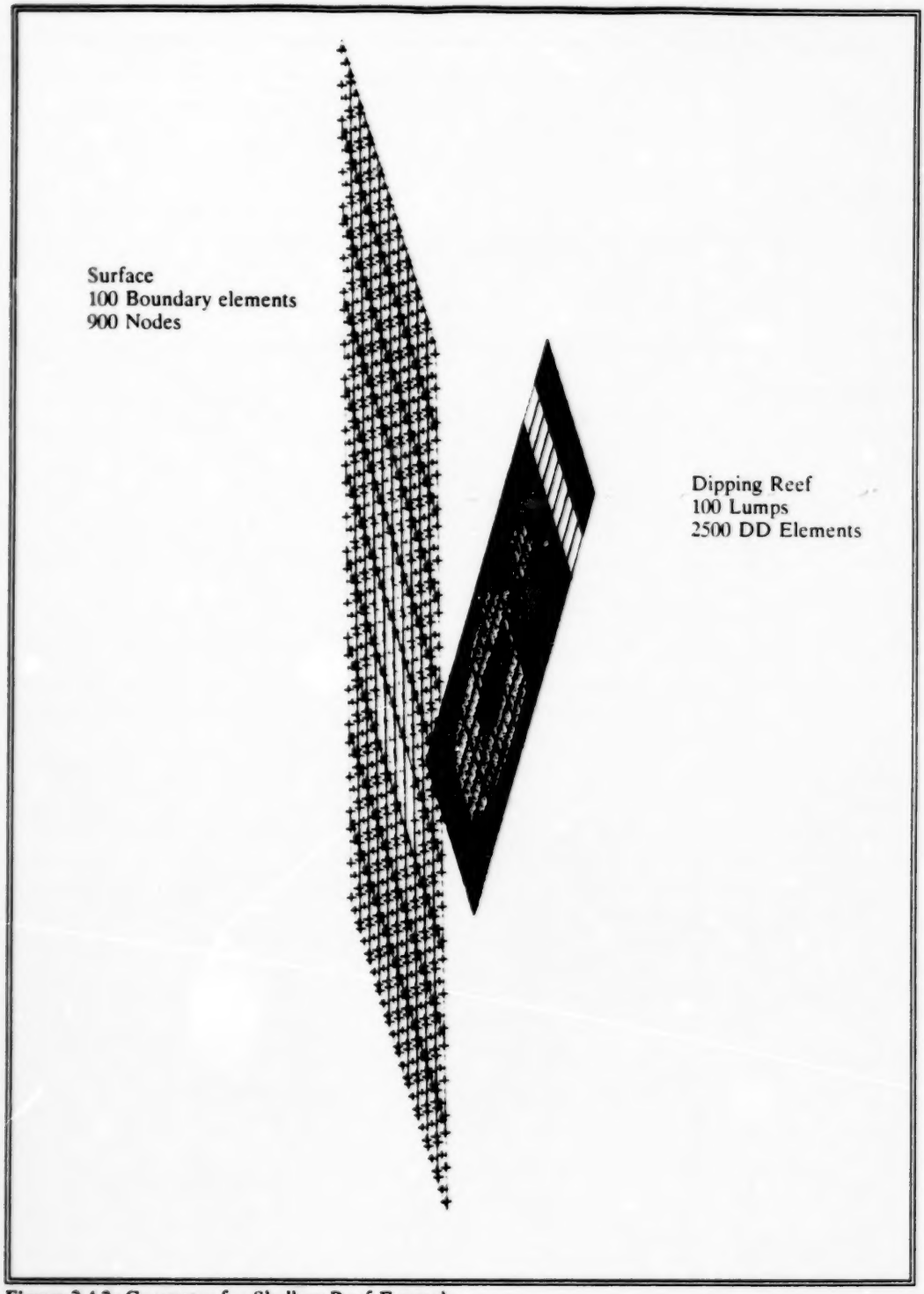

Figure 2.4.3: Geometry for Shallow Reef Example

3.0 PREPARATION OF USER INPUT FILES FOR BEAP-M

The input data for program BEAP-M consists of the same files as were required for BEAP and BEAP-DD independently. Detail for these files should be sought in the relevant documentation.

Datafiles are as follows:

D201	Global geometry (nodes and lumps) (DD)
FILE.1	Global geometry for boundary elements (BE)
D202	Displacement discontinuity lump grouping (DD)
FILE.2	Element code and subregion definitions (BE)
D203	Lump material properties
D207	Boundary conditions, benchmarks and general input
D503	Mining layout control for step "zero"
D505	Mining layout control for subsequent steps
D515	Read in a mine layout as an array

Notes

1. The same set of global nodes are used for the definition of both displacement discontinuity and boundary element nodes. This means, for example, that if node 14 is defined separately in FILE.1 and D201 to have different coordinates, the file which is processed last would overwrite the file which was first processed.

   Thus, only one set of global nodes should be prepared to cover both the displacement discontinuity and boundary elements.

2. The BEAP module M401 and the BEAP-DD module D207 are functionally similar and access the same database. Thus, one need only run one or other of these modules whilst running BEAP-M.

3. Usually, one would also only prepare datafiles for D505 or D515, but not both in one run.

4.0 DESCRIPTION OF PROGRAM MODULES

In the following paragraphs, program modules making up the BEAP-M system are described. Only those modules which are not part of BEAP or BEAP-DD are described here. Program modules may be run exactly as for BEAP or BEAP-DD.

When each program is run, the printout is written to a file TEMP.LST. If this printout is required as hard copy, then program control must be returned to DOS, and the file TEMP.LST sent to the printer using a DOS PRINT or COPY command. If programs are being run under batch control, then the PRINT commands can be built into the batch file. If the next program starts before the printing of the previous run is complete, then some of the printout can be lost. To avoid this situation, the DOS COPY command is sometimes preferable, since it waits until the printout is complete before proceeding.

BEAP Menu driver

The menu driver for BEAP contains one menu which is specific to BEAP-M. These menu items are shown below. Other selections for BEAP-M are as for BEAP-DD or BEAP.

BEAP-M OPTIONS
= = = = = = = = = = = =

0 STOP
1 CALCULATE (MIXED) LUMPING MAPS (BE-DD)
2 CALCULATE (MIXED) LUMPING MAPS (DD-BE)
3 CALCULATE (MIXED) INFLUENCE COEFFICIENTS (BE-DD)
4 CALCULATE (MIXED) INFLUENCE COEFFICIENTS (DD-BE)
5 SOLVE MIXED EQUATIONS
6 CALCULATE BENCHMARKS
7 Not yet allocated.
8 RETURN TO MAIN MENU

DB501 Calculate lumping maps (DD-BE)

This module calculates the lumping maps for displacement discontinuity / boundary element interactions (DD-BE). The effect of each displacement discontinuity element on each boundary element is assessed and the type of lumping or element-element interaction required is assessed. This module is functionally similar to M502 of BEAP and D501 of BEAP-DD. The following codes are displayed to the screen and to the print file TEMP.LST.

	Description	Size (bytes)
1	Lump-lump coefficients (for remote elements)	36
4	Lump-element coefficients	324
5	Element-lump coefficients	900
7	Element-element interaction (elements are close to each other)	8100

The total size which will be required by the file COEF.DB by DB502 is calculated and reported in TEMP.LST. The user should inspect the printout and check whether sufficient disk space is available for the remainder of the run. If the space required by these files is not availabie, then the amount of space may be reduced (at the expense of reduced accuracy) by decreasing the value of real switch number 6

```
SSW
6,1.6
0,0
```

For example, the above segment of data file D207, if read in via D207 will set the lumping transition ratio to 1.6. Values between 0.8 and 4 will usually be okay.

The lower the value of this ratio, the more 1's will be produced in the lumping map and the less will be the storage requirements. (see reference 2 for further information)

DB502 Calculate influence coefficients (DD-BE)

This module is similar to M503 and D502 of BEAP and BEAP-DD and is usually run with them and with BD502 below. The coefficients calculated here are written to file COEF.DB, the size of which should have been pre-checked using DB501 above.

BD501 Calculate lumping maps (BE-DD)

This module calculates the lumping maps for boundary element / displacement discontinuity element interactions (BE-DD). The effect of each boundary element on each displacement discontinuity element is assessed and the type of lumping or element-element interaction required is assessed. This module is functionally similar to M502 of BEAP and D501 of BEAP-DD. The following codes are displayed to the screen and to the print file TEMP.LST.

	Description	Size (bytes)
1	Lump-lump coefficients (for remote elements)	36
4	Lump-element coefficients	900
5	Element-lump coefficients	324
7	Element-element interaction (elements are close to each other)	8100

The total size which will be required by the file COEF.BD by BD502 is calculated and reported in TEMP.LST. The user should inspect the printout and check whether sufficient disk space is available for the remainder of the run. If the space required by these files is not available, then the amount of space may be reduced (at the expense of reduced accuracy) by decreasing the value of real switch number 6. See DB501 for further details.

BD502 Calculate influence coefficients (BE-DD)

This module is similar to M503 and D502 of BEAP and BEAP-DD and is usually run with them and with DB502 above. The coefficients calculated here are written to file COEF.BD, the size of which should have been pre-checked using BD501 above.

BD504 Solve equations (MIXED BE + DD)

BD504 is similar to M504 and D207 of BEAP and BEAP-DD. However, unlike the programs for calculation of lumping maps and calculation of influence coefficients, BD504 would usually be run **INSTEAD** of M504 and D507. The module would usually take hours to run, and solves the boundary element and displacement discontinuity element equation solvers.

The rates of convergence of the boundary element and displacement discontinuity components may differ and are displayed separately. The information relating to convergence of the equation solvers M504 (BEAP) and D207 (BEAP-DD) apply here. If convergence problems occur, then M504 and/or D507 can also be run to help identify problems. For example a severe mismatch of the sizes of neighboring displacement discontinuity and boundary elements could cause convergence problems.

BD507 Calculate (MIXED) benchmarks

This module is run INSTEAD of M507 and D508. It calculates the stresses and displacements at each benchmark location as the sum of the primitive stresses and the displacement discontinuity and boundary element contributions. Post processing or display of the calculated benchmark results is as for BEAP and/or BEAP-DD.

5.0 RUNNING BEAP

People using BEAP-M for the first time will run modules via the menu drivers for BEAP and BEAP-DD. However, as more familiarity is gained, it usually becomes easier to run modules directly from DOS or as part of batch files.

No attempt should be made to run BEAP-M before both BEAP and BEAP-DD have been successfully run. BEAP-M consists largely of modules from BEAP and BEAP-DD.

5.1 EXAMPLE 1

Draw up mesh on paper. Use one set of global nodes. Number displacement discontinuity lumps and boundary elements separately. (A grid of displacement discontinuity lumps may be generated as described for BEAP-DD first).

List node coordinates and element/node and displacement discontinuity lump/node definitions on paper

Capture node and element info into **FILE.1** using a text editor. Although the filename is referred to as FILE.1 here, remember that any file name may be used although the .1 extension is recommended. Be sure to make full use of the 16 character description allowed for each element. This is VERY useful for later on in the program. The small extra effort here to carefully name elements is worth it!

Create files **FILE.2** and **FILE.3** in a similar way. Often these will be created by copying these files from a previous run, and merely editing the relevant changes for the new run.

M101 Create a new database. This would initialize the database for the BEAP and BEAP-DD portions of the database.

M201 Read in FILE.1

Often there will be a data error here for a first time run. In this case, correct the data file and try again (ie M101 and M201)

If M201 has completed successfully, then run **M203** to read FILE.2 and carry out basic checks. Closely observe the displayed messages. If necessary, printout the file TEMP.LST to obtain a hard copy of these warnings. M204 may also be used to print out selected problem elements. Make corrections to the input data files and try again until all warnings have been eliminated or reasonably explained.

M301 Run this module now to prepare a plot file for the mesh. If a selected area is known to be in error, then select only those elements in the problem area. Make any required corrections and go back to running M101 again. It may also be necessary to run M401 here with a small data file containing the SSW and ISSW keywords to set the character size for the plots.

Use a plotter/display program to **view the plotfile** on the screen or plotter. (See separate section on plotfiles).

Once the data files FILE.1 and FILE.2 have been checked, then use **M204** to obtain a hard copy of the input element geometry.

M401 Read in the remaining input data including benchmark locations.

M402 Print out the Header page for this run.

M501 Assign the primitive tractions for each element.

M502 Calculate lumping maps. Copy the print file TEMP.LST to the printer and examine whether sufficient disk space is available to store the arrays BEMCO.BE and SELFCO.BE which will be created when M503 is run.

Next the BEAP-DD part of the data input is carried out.

Capture node and lump info into **D201** as for FILE.1 above.

NB **DO NOT RUN M101 HERE.** If you did, you would erase all the input data previously entered for the BEAP part of the database.

D102 Initialize the polygon master file.

D201 Read in file D201.

D102 Initialize the polygon master file.

D800 Digitizer menu

Option 1	Set up digitizer
Option 2	Digitize polygons

D206 Obtain a summary of polygon numbers and descriptions. This is important for the preparation of file D505 to follow.

D402 The polygons should be plotted for checking and for ready identification.

Create files **D202** and **D203**, **D207**, **D503** and **D505** according to the documentation for BEAP-DD.

At this stage, a complete set of data files would then be available. If the polygon master file is correct and checked, then take a backup of this file (BEMPOL.BE) so that all polygons are not lost if M101 is run again.

If D201 has completed successfully, then run **D202** to read file D202 and carry out basic checks. Closely observe the displayed messages. If necessary, printout the file TEMP.LST to obtain a hard copy of these warnings. D204 may also be used to print out selected problem elements. Make corrections to the input data files and try again until all warnings have been eliminated or reasonably explained.

D203 Read in the material properties for each lump.

D207 Read in benchmarks and primitive stresses etc as prepared in the data file D207 above. This module is equivalent to M401 and datafiles can be interchanged between the two modules.

D208 Print out the header page.

D401 Run this module now to prepare a plot file for the mesh. It may also be necessary to run D207 here with a small data file containing the SSW and ISSW keywords to set the character size for the plots.

Use a plotter/display program to **view the plotfiles** (BEMMESH.DD and possibly BEMMESHE.DD and BEMMESHN.DD) on the screen or plotter. The plot files here can be overlaid or viewed with those prepared for the BEAP part of the model prepared above.

D501 Calculate lumping maps. Examine the print file TEMP.LST to see whether there is sufficient disk space to store the influence coefficient matrix (BEMCO.DD).

D503 Initialize DD part of layout for mining step zero. This program would read in data file D503 and set the initial mine layout prior to step number 1. For example, fault elements would be initialized as such, and reef and seam elements would be initialized as unmined or solid.

D504 Increment mining step number by 1

D505 Set layout for current mining step. Here, file D505 would be read and groups of polygons would be processed against specified polygons to set mined / unmined areas in the model for the current step.

D506 Define boundary conditions for current mining step. Primitive stresses as specified by the PRIM1 and PRIM0 keywords would be applied to all mined elements.

D605 Obtain a printout of the mine layout to ensure that the polygons and groups of elements specified in file D505 have been correctly processed.

Once the various input data files have been checked, then use **D204** to obtain a hard copy of the input element geometry. This is an alternative to D605 above.

D701 One could also run **D701** to prepare a plot of the mine layout

Then use a text editor to create a batch file (eg RUN.BAT) which will run all the number crunching modules at once). Typically, this would be as follows

D502	Calculate influence coefficients.
COPY temp.lst lpt1	(copy print file to printer)
M503	Calculate influence coefficients
COPY temp.lst lpt1	
BD502	Calculate influence coefficients.
COPY temp.lst lpt1	
DB502	Calculate influence coefficients.
COPY temp.lst lpt1	
BD504	Solve equations
COPY temp.lst lpt1	
BD507	Calculate benchmarks
COPY temp.lst lpt1	
M602	Print results at all elements.
COPY temp.lst lpt1	

(The next day!) **examine the printout** to see whether the errors listed under M503 are acceptable, whether the equation solution process (DB504) has converged, and whether the remainder of printout from DB507 and other result printing modules appear to be reasonable. Do not take it for granted that if the program has run and printed results that everything is correct. Spend a few hours looking for strange results or unexpected results.

COPY BEMMESH.BE MESH.BE (take a backup copy of the plot file which contains your best mesh plot to date).

It may be necessary to run M401 here to adjust plot parameters such as number of decimals and character size. (Use keywords ISSW and SSW here).

D604 Print selected element results for selected lumps

M701 prepare a plotfile of selected element results.

D701 prepare a plotfiles of selected element results.

M509 Calculate stresses at each element centre so that these can be treated as benchmark along with those calculated using M507.

BEMPOST Perform various runs to check benchmark values for failure subject to a selected criterion or to prepare plot files.

5.2 EXAMPLE 2

A second example is provided below as an alternative to the above example. It excludes some of the modules used above.

M101	Initialize a new project
D102	Initialize polygon data base
D801	Set up digitizer
D802	Digitize polygons
D206	Print polygons
D402	Plot polygons
-	Prepare data file D201
D201	Read in global nodes and lumps (D201)
D301	Generate more (rows and columns of) lumps
D204	Summary print of lump information
-	Edit errors in D201
D201	Re-run D201 - Read global nodes and lumps
D301	Re-run D301 - Generate more lumps
D204	Summary print of lump information
D401	Plot selected lump out-lines
-	Prepare data files D202, D203 and D207
D202	Read in lump groupings (+ check geometry)
D203	Read in lump properties
D207	Read in benchmarks, primitive stresses etc
M201	Read in global nodes and boundary elements
M203	Read in element TYPE definitions and check
M204	Print selected elements or nodes
M501	Apply tractions due to primitive stresses
D208	Print out header page
D503	Initialize layout for mining step zero
D504	Increment mining step number by 1
D505	Set layout for current mining step
D506	Define boundary conditions for current mining step

NUMBER CRUNCHING

D501	Calculate lumping maps (DD)
M502	Calculate lumping maps (BE)
BD501	Calculate lumping maps (BE-DD)
DB501	Calculate lumping maps (DD-BE)
D502	Calculate influence coefficients (DD)
DB502	Calculate influence coefficients (DD-BE)
M503	Calculate influence coefficients (BE)
BD502	Calculate influence coefficients (BE-DD)
BD507	Solve equations for current mining step
BD508	Calculate benchmarks for current mining step

RESULT PRINTING, POST PROCESSING

M601	Print selected boundary element results
D604	Print displacement discontinuity element results
D605	Print out mine layout
D606	Print selected benchmarks
M701	Prepare a cross plot for selected elements
D701	Prepare a cross plot for selected lumps for a selected item
BEMPOST	Post processing of benchmark results.

6.0 REFERENCES

1 Diering, J A C, Further Developments of the Boundary Element Method with Applications in Mining. MSc Thesis, University of the Witwatersrand (1982).

2 Diering, J A C, Advanced elastic analysis of complex mine excavations using three-dimensional boundary element techniques. PhD Thesis Pretoria University, South Africa (1987).

3 Diering, J A C, Canmet Project No. 4-9147-4, Part 2 Numerical modelling (1990).

3 Diering, J A C, BEAP User manual, Canmet Project No. 4-9147-4, (1990).

4 Diering, J A C, BEAP-DD User manual, Canmet Project No. 4-9147-4, (1990).

BEAP-M APPENDIX 1 -- SAMPLE DATA FILES

Example data files :

SOLID CUBE PROBLEM WITH CONTAINED SEAM
Data file D201

```
12,1
0,0,0
 1,0,0,-10
 2,20,0,-10
 3,20,20,-10
 4,0,20,-10
 5,0,0, 0
 6,20,0, 0
 7,20,20, 0
 8,0,20, 0
 9,0,0, 10
10,20,0, 10
11,20,20, 10
12,0,20, 10
1,4,8,5,6,7
DD ELT
```

SOLID CUBE PROBLEM WITH CONTAINED SEAM
Data file D202

```
1,1,8,1,1,1,1,3,0,0
0,0,0,0,0,0,0,0,0,0
```

SOLID CUBE PROBLEM WITH CONTAINED SEAM
Data file D203

```
1,1,1.0,85,1,.2,.002
500,200,4,35,2,0,0,0,0,0
0,0,0,0,0,0,0
```

SOLID CUBE PROBLEM WITH CONTAINED SEAM
Data file FILE.1

```
12,10
0,0,0
 1,0,0,-10
 2,20,0,-10
 3,20,20,-10
 4,0,20,-10
 5,0,0,  0
 6,20,0,  0
 7,20,20,  0
 8,0,20,  0
 9,0,0, 10
10,20,0, 10
11,20,20, 10
12,0,20, 10
 1,4,1,4,3,2
BOT
 2,4,5,1,2,6
LOWER FRONT
 3,4,6,2,3,7
LOWER RIGHT
 4,4,8,7,3,4
LOWER BACK
 5,4,5,8,4,1
LOWER LEFT
 6,4,9,5,6,10
UPPER FRONT
 7,4,10,6,7,11
UPPER RIGHT
 8,4,12,11,7,8
UPPER BACK
 9,4,9,12,8,5
UPPER LEFT
10,4,9,10,11,12
TOP
```

SOLID CUBE PROBLEM WITH CONTAINED SEAM
Data file FILE.2

```
1,10,1,1,1,1,0,2,0,0
0,0,0,0,0,0,0,0,0,0
```

SOLID CUBE PROBLEM WITH CONTAINED SEAM
Data file D207 or FILE.3

```
HEADING
 BEAP-M CUBE test 10 BE and 1 DD
SUBS
1
1,100,.3,1,0
SSW
6,2.5
17,0.6,char size
20,1,disp scale factor
0,0
ISSW
11,0
12,0
20,2,ndec
0,0
SPTRAC
10,10
1,9,0,0,-10
0,0
BOUNDR
1,1,5
2,2,1
3,3,1
4,4,4
5,5,3
6,6,1
7,7,1
8,8,4
9,9,3
0,0,0
ITERATIONS
20,0.8,.0010,4,1.03
INTEGRATION (high accuracy)
8,6,4,2, 1.5,1.0,.5,.4,.3,0
.70
BENCH
1,10,10,-5
Lower middle
2,10,10,5
Upper middle
3,2,2,-2
Close F/W:1
4,2,10,-2
Close F/W:2
5,10,10,-2
Close F/W:3
6,2,2, 2
Close H/W:1
7,2,10, 2
```

```
Close H/W:2
8,10,10, 2
Close H/W:3
-99,0,0,0
END
```

SOLID CUBE PROBLEM WITH CONTAINED SEAM
Data file D503

```
0,0,0,0,0,2      (All elements initially unmined)
```

SOLID CUBE PROBLEM WITH CONTAINED SEAM
Data file D504

```
1,0,0,0,0,2      (All elements unmined for step 1)
2,0,0,0,0,1      (All elements mined for step 2)
```

Dipping reef example for BEAP-M
Starter file for initial grid definitions

```
8,26
0,0,0
1,250,250,-60
2,730,250,-200
3,730,750,-200
4,250,750,-60
5,0,0,0
6,1000,0,0
7,1000,1000,0
8,0,1000,0
1,4,1,2,3,4
REEF PLANE
26,4,5,6,7,8
SURFACE
```

Dipping reef example
Data File D201

```
80,25
0,0,0
 1 250 250 -60
 2 730 250 -200
 3 730 750 -200
 4 250 750 -60
 5   0   0   0
 6 1000   0   0
 7 1000 1000   0
 8   0 1000   0
 9 250 250 -60
10 250 350 -60
11 250 450 -60
12 250 550 -60
13 250 650 -60
14 250 750 -60
15 346 250 -88
16 346 350 -88
17 346 450 -88
18 346 550 -88
19 346 650 -88
20 346 750 -88
21 442 250 -116
22 442 350 -116
23 442 450 -116
24 442 550 -116
25 442 650 -116
26 442 750 -116
27 538 250 -144
28 538 350 -144
29 538 450 -144
30 538 550 -144
31 538 650 -144
32 538 750 -144
33 634 250 -172
34 634 350 -172
35 634 450 -172
36 634 550 -172
37 634 650 -172
38 634 750 -172
39 730 250 -200
40 730 350 -200
41 730 450 -200
42 730 550 -200
43 730 650 -200
44 730 750 -200
45   0   0   0
46   0 200   0
47   0 400   0
48   0 600   0
```

```
49   0 800   0
50   0 1000   0
51 200   0   0
52 200 200   0
53 200 400   0
54 200 600   0
55 200 800   0
56 200 1000   0
57 400   0   0
58 400 200   0
59 400 400   0
60 400 600   0
61 400 800   0
62 400 1000   0
63 600   0   0
64 600 200   0
65 600 400   0
66 600 600   0
67 600 800   0
68 600 1000   0
69 800   0   0
70 800 200   0
71 800 400   0
72 800 600   0
73 800 800   0
74 800 1000   0
75 1000   0   0
76 1000 200   0
77 1000 400   0
78 1000 600   0
79 1000 800   0
80 1000 1000   0
 1 4  9 15 16 10
reef row 1
 2 4 10 16 17 11
reef row 1
 3 4 11 17 18 12
reef row 1
 4 4 12 18 19 13
reef row 1
 5 4 13 19 20 14
reef row 1
 6 4 15 21 22 16
reef row 2
 7 4 16 22 23 17
reef row 2
 8 4 17 23 24 18
reef row 2
 9 4 18 24 25 19
reef row 2
10 4 19 25 26 20
reef row 2
11 4 21 27 28 22
reef row 3
```

```
12 4 22 28 29 23
reef row 3
13 4 23 29 30 24
reef row 3
14 4 24 30 31 25
reef row 3
15 4 25 31 32 26
reef row 3
16 4 27 33 34 28
reef row 4
17 4 28 34 35 29
reef row 4
18 4 29 35 36 30
reef row 4
19 4 30 36 37 31
reef row 4
20 4 31 37 38 32
reef row 4
21 4 33 39 40 34
reef row 5
22 4 34 40 41 35
reef row 5
23 4 35 41 42 36
reef row 5
24 4 36 42 43 37
reef row 5
25 4 37 43 44 38
reef row 5
```

Dipping reef example
Data File D202

```
 1, 25,1,1,1,1,1,3,2,0
0,0,0,0,0,0,0,0,0,0
```

Dipping reef example
Data File D203

```
1,25,1.0,85,1,.2,.002
5000,3000,4,35,2,.5,50,2,.02,.1
0,0,0,0,0,0,0
```

Dipping reef example
Data File FILE.1

```
80,25
0,0,0
 1 250 250 -60
 2 730 250 -200
 3 730 750 -200
 4 250 750 -60
 5  0  0  0
 6 1000  0  0
 7 1000 1000  0
 8  0 1000  0
 9 250 250 -60
10 250 350 -60
11 250 450 -60
12 250 550 -60
13 250 650 -60
14 250 750 -60
15 346 250 -88
16 346 350 -88
17 346 450 -88
18 346 550 -88
19 346 650 -88
20 346 750 -88
21 442 250 -116
22 442 350 -116
23 442 450 -116
24 442 550 -116
25 442 650 -116
26 442 750 -116
27 538 250 -144
28 538 350 -144
29 538 450 -144
30 538 550 -144
31 538 650 -144
32 538 750 -144
33 634 250 -172
34 634 350 -172
35 634 450 -172
36 634 550 -172
37 634 650 -172
38 634 750 -172
39 730 250 -200
40 730 350 -200
41 730 450 -200
42 730 550 -200
43 730 650 -200
44 730 750 -200
45  0  0  0
46  0 200  0
47  0 400  0
48  0 600  0
```

```
49   0 800   0
50   0 1000   0
51 200   0   0
52 200 200   0
53 200 400   0
54 200 600   0
55 200 800   0
56 200 1000   0
57 400   0   0
58 400 200   0
59 400 400   0
60 400 600   0
61 400 800   0
62 400 1000   0
63 600   0   0
64 600 200   0
65 600 400   0
66 600 600   0
67 600 800   0
68 600 1000   0
69 800   0   0
70 800 200   0
71 800 400   0
72 800 600   0
73 800 800   0
74 800 1000   0
75 1000   0   0
76 1000 200   0
77 1000 400   0
78 1000 600   0
79 1000 800   0
80 1000 1000   0
 1 4 45 51 52 46
surface row 1
 2 4 46 52 53 47
surface row 1
 3 4 47 53 54 48
surface row 1
 4 4 48 54 55 49
surface row 1
 5 4 49 55 56 50
surface row 1
 6 4 51 57 58 52
surface row 2
 7 4 52 58 59 53
surface row 2
 8 4 53 59 60 54
surface row 2
 9 4 54 60 61 55
surface row 2
10 4 55 61 62 56
surface row 2
11 4 57 63 64 58
surface row 3
```

12 4 58 64 65 59
surface row 3
13 4 59 65 66 60
surface row 3
14 4 60 66 67 61
surface row 3
15 4 61 67 68 62
surface row 3
16 4 63 69 70 64
surface row 4
17 4 64 70 71 65
surface row 4
18 4 65 71 72 66
surface row 4
19 4 66 72 73 67
surface row 4
20 4 67 73 74 68
surface row 4
21 4 69 75 76 70
surface row 5
22 4 70 76 77 71
surface row 5
23 4 71 77 78 72
surface row 5
24 4 72 78 79 73
surface row 5
25 4 73 79 80 74
surface row 5

Dipping reef example
Data File FILE.2

1,25,1,1,1,1,0,2,0,0
0,0,0,0,0,0,0,0,0,0

Dipping reef example
Data File D207 or FILE.3

```
HEADING
Dipping reef test (25 surface elements and 25 DD reef lumps)
PRIM1
-0.0540,0,0
0,-0.0405,0
0,0,-0.027
ITERATIONS
20,1.0,0.001,5,1.35
INTEGRATION
4,2,1.2,0.8,0.5,0.4
0.75
SSW
6,1.6
17,1
18,1
19,1
20,1
0,0
ISSW
11,0
20,0
0,0
SUBS
1
1,30000,0.25,1,0
BENCH
1,-40,500,0
SURF TEST 1
2,500,-40,0
SURF TEST 2
3,250,250,-30
BELOW NOD1
4,250,500,-30
DEPTH 30
5,500,500,-120
CENTRE -130
6,500,500,-100
CENTRE -100
7,500,500,-70
CENTRE -70
8,500,500,-40
CENTRE -40
-99,0,0,0
END
```

Dipping reef example
Data File D503

0,0,0,1,25,2

Dipping reef example
Data File D504

1,0,0, 1,15,1
1,0,0,16,20,2
1,0,0,21,25,1
2,0,0,17,18,1